Climate Change Perceptions and Adaptation Strategies by Forest Adjacent Communities in Kilombero District Tanzania

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Abstract
Climate change is a global challenge to both sustainable livelihoods and economic development. Tanzania has been affected by climate change due to primary dependence on rain-fed agriculture. Despite several studies being able to explore climate change farmers' perceptions and adaptation in Tanzania, little attention has been to humid areas specifically forest adjacent communities. This study assessed the perceptions and adaptation strategies developed by forest adjacent communities against climate change effects in Kilombero District, Tanzania. Data collection involved use of household questionnaire, key informant interviews, focus group discussions and participant observations. Results showed that the majority of communities perceive the climate to have changed as evidenced by increase in temperature and unpredictable rainfall over the past decades. This was further evidenced by frequent occurrence of floods, increased dry spells during rainy season coupled with decreased water sources, emergence of new pests and diseases, and fluctuations in fruiting and flowering seasons for plant resources in the forests. The communities' perceptions are in line with existing empirical climate data for Kilombero meteorological station where temperature and rainfall have indicated an increasing trend with fluctuations in some years. The perceived change in climate has impacted different sectors mostly agriculture as the main livelihood source. Local communities are responding through different coping and adaptation strategies, such as crop diversification, changing cropping calendar, adopting modern farming technologies, increasing reliance on Non-Timber Forest Products (NTFPs), animal rearing and petty trading. Household size, residence period, land ownership, and household income were the socio-economic factors that influenced coping and adaptation strategies positively and significantly. In conclusion, forest adjacent communities perceive the climate to have changed as evidenced by different climatic indicators. In actual fact the area seem to have experienced climate variability and communities have responded differently by developing both coping and adaptation strategies within the farming and non-farming context. The study recommends a need for provision of weather forecast to the area for preparedness. The need for daily recording of climatic events by meteorological stations in the study area and other places in Tanzania is crucial for future confirmation of climate change. The observed potential coping and adaptation strategies need to be prioritized, strengthened and developed to ensure livelihood sustainability in future.
Keywords: climate change perceptions; forest adjacent communities; coping and adaptation strategies, Tanzania

1.0 Introduction

Climate change is among the key challenges that hinder sustainable livelihoods and economic development, particularly for developing countries like Tanzania. Tanzania has recently been reported to be affected by climate change since it depends primarily on rain-fed agriculture, with only 2% of arable land having irrigation facilities (Eriksen *et al.,* 2005; Shemsanga *et al.,* 2010; Ahmed *et al*., 2011). Local communities with low adaptive capacity are thought to be more vulnerable to the adverse effects of climate change, which contributes to the loss of their natural resources (Eriksen *et al*., 2005; Paavola, 2008). The report by the IPCC (2014) indicates that there will be an increase in global temperature by an additional 1.4 to 5.8 ºC by 2100 and rainfall will continue to increase but vary by region, with some regions showing decreasing rainfall. Climate predictions in Tanzania (URT, 2005; 2007) show that the mean daily temperature will rise by 3 – 5ºC throughout the country and the mean annual temperature by 2 – 4ºC. There will also be an increase in rainfall in some parts while other parts will experience decreased rainfall. Predictions further show that areas with a bimodal rainfall pattern will experience increased rainfall of 5–45% and those with unimodal rainfall pattern will experience decreased rainfall of 5–15%. According to URT (2012), the change in temperature and precipitation patterns have led to increased risk of recurrent droughts and devastating floods, threats to biodiversity, an expansion of plant and animal diseases and a number of potential challenges for public health. Furthermore, Bakengesa *et al.* (2011) in Kilombero Ramsar Site revealed that change in rainfall patterns and inflow have affected habitats and dependent wildlife. This could probably provide initial indications that the climate has not been stable in Kilombero district.

According to Ban and Hawkins (2000), perception has been defined as the process by which information or stimuli is received from our environment and transformed into psychological awareness.

Knowledge, interest, culture and many other social processes do shape the behaviour of an actor who uses the information and tries to influence that particular situation or phenomenon (RECOFTC, 2001). Perception is important in climate change because it is one of the elements that influence adaptation process. The forest adjacent communities' ability to perceive effects of climate change is a key precondition for their choice to adapt (Maddison, 2006, 2007; Gbetibouo, 2009). Adaptation to climate change requires that forest adjacent communities first notice that the climate has changed, and then identify useful adaptations and implement them (Maddison, 2006, 2007). A better understanding of forest adjacent communities' perceptions of climate change, on-going adaptation measures, and the decision-making process is important to inform policies aimed at promoting sustainable adaptation strategies for all sectors of the economy. For example, currently in most areas, local communities perceive that the climate has become hotter and the rains less predictable and shorter in duration. The change in rainfall and temperature trends and pattern (URT, 2007; 2012) is expected to pose adverse effects on livelihoods of the people in most parts of the country. Already the frequency and intensity of extreme weather events such as drought and floods have increased in some parts of Tanzania affecting climate sensitive sectors such as agriculture (URT, 2008). A number of climate change perceptions and adaptation studies done in Tanzania (Naess, 2008; Lema and Majule, 2009; Nelson and Stathers, 2009; Lyimo and Kangalawe, 2010; Mongi *et al*., 2010; Swai *et al.,* 2012; Kangalawe and Lyimo, 2013; Kihupi *et al*., 2015) have focused on smallholder farmers in semi-arid areas with little attention to humid areas and specifically the forest adjacent communities whom the majority have different livelihood activities.

Due to the current thought of adverse effects of climate change, forest adjacent communities in Kilombero District including their livelihood assets are mostly vulnerable to unpredictable floods and prolonged dry spells during rainy season necessitating the need for coping and adaptation strategies to be uncovered (Chamwali, 2000; Abdulla, 2000). According to the National Climate Change Strategy of Tanzania (URT, 2012), floods, landslides and associated vector and water borne diseases are on the increase in Kilombero District, whereby elderly people, women and children are more vulnerable. Similarly, the recent Fifth Assessment Report of the IPCC, by Smith *et al.* (2014a) showed that, elderly people are usually at greater risk from climate change extreme events due to being less mobile than younger adults as well as the difficulties they have to avoid hazardous situations. For instance, in April 2011 floods in the Kilombero valley demolished about 663 houses, submerged 2,942, and made 9,000 people homeless (URT, 2012). In the same case, food stores, farms and other infrastructures were destroyed and approximately 2,256 hectares of crops including paddy and maize were as well destroyed. Due to experiencing adverse effects of climate change, coping and adaptation by forest adjacent communities is inevitable. According to Smit and Wandel (2006) adaptation is related to building resilience, and recognised as a key response to reduce vulnerability to climate change. IPCC (2007a) defined adaptation as initiatives and measures to reduce the vulnerability of natural and human systems against actual or expected climate change effects. It could be anticipatory and reactive, private and public, and/or autonomous and planned adaptation. On the on the other hand, UNFCCC (2009) defines adaptation as the adjustment in natural or human systems in response to actual or expected climate stimuli or their effects, which moderated harm or exploits beneficial opportunities. In the context of this paper the three definitions have been adopted. It has been urged by Reuveny (2007) that, people adapts to climate change in three main ways: stay in a place and do nothing, accepting the costs; stay in the place and mitigate changes; or leave affected areas.

This study assessed the perceptions and adaptation strategies developed by forest adjacent communities against climate change effects in Kilombero District, Tanzania. The study addressed the following specific questions: 1) how do the forest adjacent communities perceive climate change and its effects in line with existing empirical data? (2) how are the forest adjacent communities cope and adapt to the effects of climate change? (3) what socio-economic factors are influencing their coping and adaptation strategies? The findings have generated scientific information that will be incorporated into the climate change adaptation database. Furthermore, results are useful to policy and decision makers within the natural resource sectors in order to implement existing policies and strategies through developing and strengthening the existing coping and adaptation strategies such as the National Agriculture and Forest policies; National Adaptation Programme of Action (NAPA), REDD+ and the National Climate Change strategies.

2.0 Methodology

2.1 Description of the study area

This study was conducted in three selected villages of Mpofu, Njage and Miwangani in Kilombero District (Fig. 2). The choice of the study area was based on the vicinity of villages to Iyondo Forest Reserve and wooded grassland which are important to the adjacent communities' livelihood sustenance. The forest resources are also important in increasing resilience of the local communities against adverse effects of climate change (Nkem *et al*., 2010; Smith *et al*., 2014b).

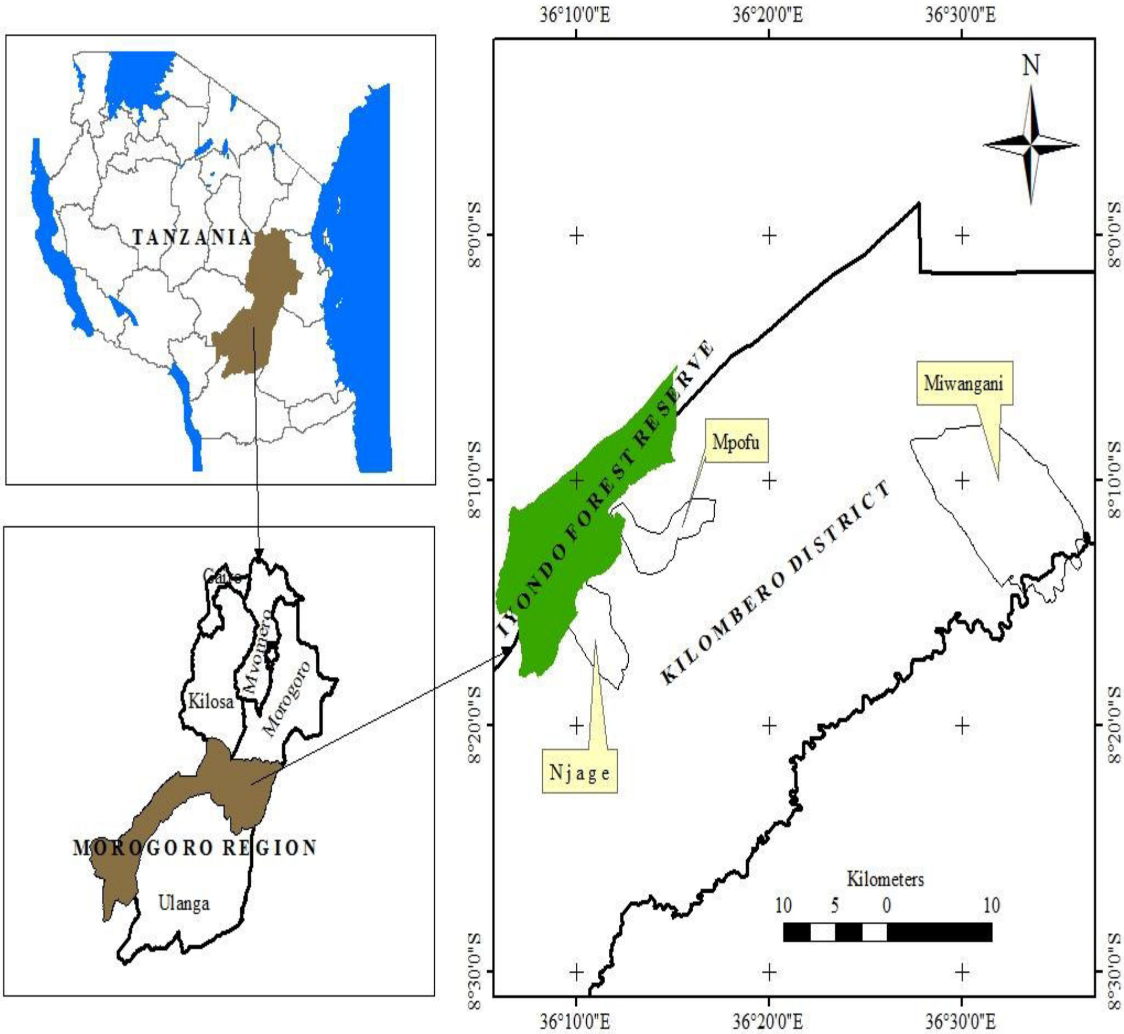

Figure 1: A map showing location of study villages in Kilombero District, Tanzania

The climate in the study area is marked by a rainy and dry seasons which are further distinguished into four sub season namely; hot rainy season from December to March, cool rainy season from April to June, cool dry season from July to August, hot dry season from September to November, with annual rainfall and temperature ranging between 1200 and 1800 mm and 26 °C to 32 °C, respectively (Erlanger *et al.,* 2004; Hetzel *et al.,* 2008). However, the rains are currently unpredictable whereby, the onset and cessation is inconstant. The mean elevation in the study villages ranges from 262 to 358 m a.s.l. The general topography of the area is a flat land with loamy and sandy soils and some cotton black soil in flooded areas. In hilly areas, the soils are sandy loam over crystalline rocks (Lovett and Pocs, 1993). Access to the study villages is through an earth road running from Ifakara Town to Mlimba as well as the railway line of Tanzania-Zambia Railway Authority (TAZARA) that extends from Dar es Salaam (Tanzania) to Kapiri Mposhi (Zambia). Ethnic groups are seemingly diverse, but still share similar livelihoods and socio-cultural norms. Table 1 indicates some physical and demographic characteristics of the study area.

Table 1: Some characteristics of Mpofu, Njage and Miwangani villages in the study site

Characteristics	Mpofu	Njage	Miwangani
Geographic position	08° 12' 57" S; 36° 14' 333" E	08° 15' 26" S; 36° 10' 08" E	08° 11' 06" S; 36° 32' 11" E
Mean altitude (m)	295	312	272
Population of people*	3 123	3 402	2 545
Average household size**	4.72	4.78	4.93
Average land size (ha)/household	1.32	1.30	1.77
Crops grown	Main (banana, maize, rice); others (sesame, cocoa, sunflower, cassava).	Main (rice, banana, maize); others (sesame, cassava).	Main (rice, maize); others (sesame, cassava, banana).
Ethnic groups	Main (hehe, nyakyusa, bena, ndali); others (sukuma, makua, kerewe, gita, ndamba, pogolo, nyamwezi, haya, safa and kinga).	Main (hehe, bena, nyakyusa, ndamba); others (sukuma, pogolo, kerewe, gita, nyamwezi, chaga and matumbi).	Main (ndamba, pogolo, hehe, and sukuma); others (nyakyusa, ndali, luguru, bena, kinga and matumbi).

*Housing and Population Census of 2012 (URT, 2013); **number of household in each village is indicated in Table 2

2.2 Data collection methods

Different methods and techniques were employed to collect qualitative and quantitative data from both primary and secondary sources. Primary data sources include participatory assessment and structured interview for households. Participatory assessment methods included Focus Group Discussions (FGDs) and key informant interviews. FGDs comprised of 10-12 people who were randomly selected aged 40 years and above representing various livelihoods and gender in each village were held. The key informants were drawn from District Agricultural and Forest officers, village leaders, Village Agricultural Extension officers and elderly people in the respective villages. The tools aimed at capturing information on the forest adjacent communities' perception on climate change; trend of rainfall and temperature, change in crop types and cropping pattern.

Household interviews were conducted using structured questionnaire to complement the qualitative information from participatory assessment. The household questionnaire was used to collect data related to; demography, forest adjacent communities' perceptions and responses to the adverse climate change effects as well as the socio-economic factors influencing climate change adaptation strategies in the study area. A sampling intensity of 7 to 10% of the village households was randomly selected for interview (Table 2), with the assumption that their livelihoods face adverse effects of climate change. Boyd and Stach (1988), recommended a sampling intensity of not less than 5% while according to Bailey (1994), a sample of at least 30 units is sufficient irrespective of the population size. A total of 180 households were selected.

Table 2: Sample size distribution in the study area

Village	Number of households	Sample size (n)	Sampling intensity (%)
Mpofu	714	62	9
Njage	868	60	7
Miwangani	581	58	10
Total	2163	180	

Secondary data from both published and unpublished literature from various sources were used to supplement primary data. Climatic data mainly rainfall and temperature from the Tanzania Meteorological Agency (TMA) for a span of 30 (1980–2010), and 20 (1990–2010) years, respectively were also used to supplement communities perceptions on climate change in the study area.

2.3 Data Analysis

Content method and Statistical Package for Science (SPSS) were used to analyse qualitative and quantitative data respectively. Qualitative data collected through FGDs and key informant interview were categorized into meaningful units and themes for triangulation with the quantitative information. Quantitative data mainly demographic characteristics, communities' perceptions to climate change effects and adaptation measures were coded, processed and analysed using SPSS computer software. Descriptive and inferential statistics involved use of frequency distribution, crosstabulation and multinomial logistic regression. Frequency distribution and cross tabulation were used to compare different variables within and across study villages.

The multinomial logistic regression analysis was used to analyse the socio-economic factors influencing adoption of developed climate change coping and adaptation strategies. The multinomial logistic regression is an analytical approach that is commonly used in adoption decision studies involving more than two multiple choices (Green, 2000). In this case there were three categories: households without adoption strategies; households with one up to three strategies and lastly households with more than three strategies. The approach is also appropriate for evaluating alternative combinations of adaptation strategies, including individual strategies (Wu and Babcock, 1998). The following multinomial logistic regression equations were used:

Log [P(adoption1-3 strategies/(1-P(no-adoption)]= $\beta_0+\sum \beta_i X_i+\varepsilon_1$……..…..…………………(1)

Log [P(adoption>3 strategies/(1-P(no-adoption)]= $\beta_0+\sum \beta_i X_i+\varepsilon_1$………………………..……(2)

Where;

P = probability function that a household adopts 1-3 strategies or more than 3 strategies

(1 - P) = is the probability that a household does not adopt to any strategies

β_0 = constant term of the model without the independent variables

β_s = are parameter estimates for the independent variable, X

ε = is an error term which represents unobservable factors assumed to be independently distributed over the survey period;

X = is a vector of socio-economic factors, which include.

Age (X_1) – this is a continuous explanatory variable measured from the age of respondent. Studies show presence of relationship between age of household head and adaptation (Dolisca *et al.,* 2006; Tazeze *et al*., 2012).

Household size (X_2) – this is a continuous explanatory variable that was measured from number of members of the respondents' household.

Education level (X_3) – is a dummy explanatory variable which was given 1 to denote respondents with formal education (primary, secondary, college and university) and 0 for otherwise. Educated and experienced head of households are expected to have more knowledge and information about climate change and agronomic practices that they can use in response.

Residence period (X_4) – this is a continuous explanatory variable that was measured from number of years the respondent has lived in the study area. Duration a household head spent in the area for living was related to increased experience about the area. This included gained knowledge and information about agronomic practices and climate change.

Land ownership (X_5) – is a binary explanatory variable that was given 1, when respondent declared to own land and 0 for otherwise.

Household income (X_6) – this is a continuous explanatory variable that was measured from the annual total household income. The income was mainly from agriculture, formal employment, petty business, casual labour, sales of NTFPs, livestock and remittances.

Forest access rules (X_7) – this is a binary explanatory variable that was given 1, when respondent declared that rules and regulations enable access to forest products and 0 for otherwise.

3.0 Results and Discussion

3.1 Forest Adjacent Communities' perception of climate change

The majority of forest adjacent communities perceived the climate of their area to have changed as indicated by increase in amount of rainfall (68%), delay in onset of rain (82%) with high intensity (62%) and temperature increase (75%) in the area (Table 3).

Table 3: Forest adjacent communities' perception on climate change in the study area

Indicator	Attributes	Response (%)
Rainfall amount	Increase	67.8
	Decrease	26.6
	No change	5.50
Rain season	Delay in onset	82.2
	Early cessation	35.4
Rainfall intensity	High rains and for short time	61.6
	Little rains and for long time	22.7
	Little rains and for short time	11.2
	No change	4.4
Temperature	Increase	74.5
	Decrease	19.3
	No change	6.1

Focus group discussions noted that in the past (1990s and beyond) the rainy season started in November, but currently rains are not as stable as sometimes rains start either in mid December or early January. Similarly, the first rain season cessation was mentioned to be earlier than it was in the past two decades (1990s to 1980s). These two perceptions were consistent with the perceived shorter rainy season in all study sites. The shorter rain season resulted into reduction in crop yields because some of the crops failed to mature. The current findings are in line with those by Urama and Ozor (2011) in the Western and Central Africa where they revealed a decrease in length of the growing season and yield potentials due to climate change and called for advocated agricultural innovations for adaptation.

Climatic hazards such as increasing rainfall amount as well as its intensity was reported to cause floods on agricultural fields, impacting the livelihood of forest adjacent communities (Table 4) and mostly the Miwangani village communities who are located on lower elevation level compared to Mpofu and Njage villages. Houses and roads were also reported to be destroyed by floods in all villages therefore increasing the number of homeless households and disconnecting communication especially access to social services such as hospitals and schools.

Table 4: Effects of climate change to forest adjacent communities' livelihoods

Climate change effect	Responses (%)
Effects of floods on agricultural fields	98.9
Wilting of crops due to moisture stress	78.6
Settlements destructions due to floods	14.0
Increased outbreak of human diseases	23.9
Increased outbreak of pests and diseases in crop and livestock	17.9
Drying of rivers and dams due to dry spells	13.0
Increased wild fires on forests and grasslands in prolonged dry season	2.9
Roads destructions due to floods	3.5

Increased temperature was reported to cause moisture stress on crops as well as increase in outbreaks of both animal and plant pests and diseases. The majority of the interviewed respondents (79%) reported that crops have been wilting due to moisture stresses, thus reducing crop yields. Moisture stresses has also been related to outbreak of army – worms (pests) as well as Rice Yellow Mottle Virus (RYMV) disease in rice crop. Results concur with observations by Akponikpe *et al.* (2010) in West Africa and Sanga *et al.* (2013) in Pangani River Basin and Pemba in Tanzania, where moisture stress was a fundamental cause of susceptibility of the crops to other stresses like pests and diseases, leading to reduced crop yield. According to Allarangaye *et al.* (2006) and Michel *et al.* (2008), RYMV is the most important virus disease for rice in Africa which reduces paddy productivity.

Increased temperature was also related to increased dry spells during rainy season which was the main cause for drying of rivers, streams and dams, hence water shortages to communities (Table 4). The shortage of water at household level was claimed to be the source of outbreak of human diseases such as diarrhoea, typhoid, dysentery and amoeba. It was also noted that, cholera occurred much during periods of floods due to increased rate of germs that cause the disease. Similar observations have been pointed out by Traerup *et al.* (2010) that, high rate spread of waterborne diseases may be boosted by extreme climate conditions that enable the disease vectors spread more easily. Other human diseases that were reported to be associated with increased temperature in the study area include malaria, skin rashes, tick borne diseases and diarrhoea.

The forest adjacent communities' perceptions on change in climate have been supported by existing empirical data from the Tanzania Meteorological Agency (TMA). The empirical data showed that rainfall and temperature in the study area have been unpredictable (Fig. 2 and 3). The rainfall pattern from 1980 to 2010 showed a trend of decrease in total rainfall received for the past three decades. This implied that the study area has been receiving high rains for short period, as was perceived by the majority. Furthermore, temperature trends have indicated an increase in both maximum and minimum average annual temperature, in the study area over the past decades, implying prolonged dry spells in the area.

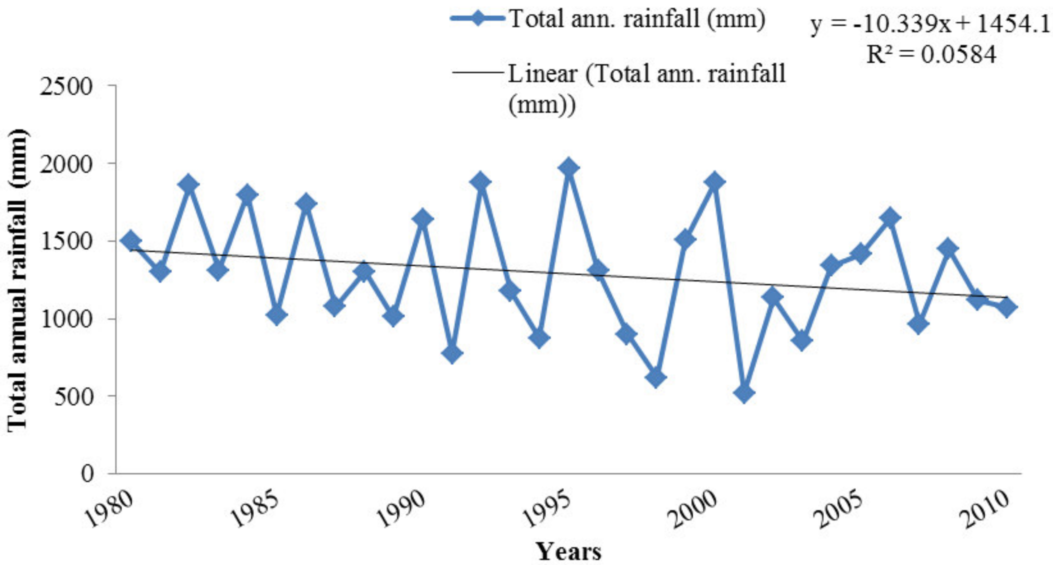

Figure 2: Total annual rainfall (mm) recorded between 1980 and 2010 around the study area

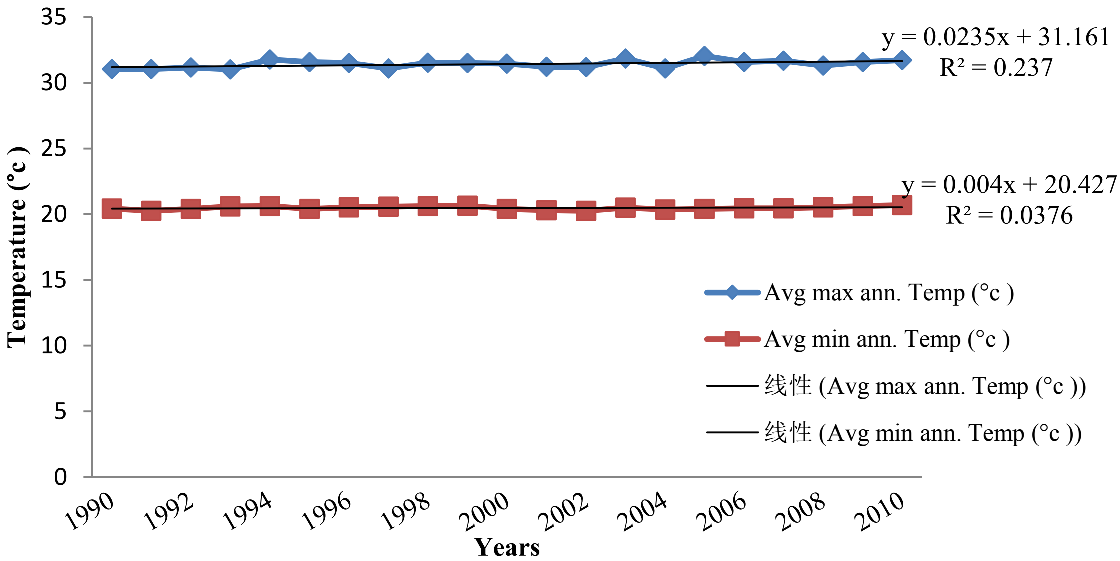

Figure 3: Average maximum and minimum temperature (°C) recorded between 1990 and 2010 around the study area

The prolonged dry spells especially during rainy season could increase chance for termites to attack crops, construction materials such as thatch grass, withies and ropes and in turn collection of construction materials from the wild increases hand in hand with reduced overall productivity at household level. The increase in termite attack has been associated with climate change-induced dry spells (Sileshi *et al*., 2009). Prolonged dry spells were also reported to affect forests and grasslands due to increased wildfires. Wildfires were reported to be a serious threat in Njage village forest as well as in the grasslands in Miwangani and Mpofu village. For example, respondent reported that Iyondo Forest Reserved has been much vulnerable to wildfires especially in dry season. Livestock, mainly cattle and local chicken were reported to be vulnerable to both prolonged dry spells and flooding, due to scarcity of feeds and pastures. Similar observations were noted by the IPCC Fourth Assessment Report (IPCC, 2007b) where extended warm periods and increased droughts led to increase in water stress in forests and grasslands and increased frequency and intensity of wildfires. According to Khandlhela and May (2006), poor quality of pastures due to floods and dry spells increased vulnerability of cattle and goats to pests and diseases, thus causing deaths in Limpopo Province, South Africa.

3.2 Forest adjacent communities' responses to climate change effects

Following the realised adverse effects of climate change, forest adjacent communities have acted in numerous ways. As Reuveny (2007) urged on how people respond to climate, in this study forest adjacent communities were responding to climate change by staying in the place and mitigating the changes through various coping and adaptation strategies. Their responses based on the main adverse effects of climate change to their livelihoods, included adaptation against dry spells, floods as well as pest and diseases.

3.2.1 Response to dry spells

During FGDs participants reported that, the government provided relief food for communities to cope with food shortage. However, the food supplied was not sufficient to carter for reasonable number of days that the communities were in need. Apart from the government strategy, the majority of forest adjacent communities in the study area revealed to respond to effects of dry spells that occurred during rainy season through crop diversification, changing cropping calendar and adopting modern farming techniques (Table 5). Few of the respondents (8%) did not have adaptation strategies; however during FGDs it was revealed that, some of them practiced adaptation strategies unknowingly.

Table 5: Developed forest adjacent communities strategies against dry spell effects in the study area

Strategies	Responses (%)
Crop diversification	85.0
Changing cropping calendar	80.1
Adopting modern faming technologies	62.7
No adoption	8.4

Crop diversification involved growing different varieties of food and cash crops, some of which are resistant to dry spells and some pests and diseases. Crop diversification aimed to supplement traditional crops with non-traditional. Traditional crops were rice (*Oryza sativa* (L.)), banana (*Musa* spp.) and maize (*Zea mays* (L.)) (Table 6).

Table 6: Main crops (traditional and non-traditional) grown in the study area

Crops grown		Responses (%)
Botanical names	Common names	
Traditional crops		
Oryza sativa (L.)	Paddy	88.7
Zea mays (L.)	Maize	89.0
Musa spp.	Banana	52.0
Cocos nucifera (L.)	Coconut	1.3
Non-traditional crops		
Sesamum indicum (L.)	Sesame	20.0
Manihot esculenta Crantz	Cassava	22.3
Ipomoea batatas (L.)	Sweet potatoes	17.0
Theobroma cacao (L.)	Cocoa	3.0
Arachis hypogaea (L.)	Groundnuts	2.3
Cajanus cajan (L.)	Pigeon peas	12.7
Vigna unguiculata (L.) Walp	Cow peas	4.3
Helianthus annuus (L.)	Sunflower	3.0

The study also observed forest adjacent communities growing fast growing food crop varieties including *Stuka* and *Staha* for maize and SARO 5, TXD 88 and TXD 85 for rice. Cash crops like sesame, cocoa and sunflower constituted recently introduced crops to diversify agricultural activities. In Mpofu for example, sesame has been grown since 2000, while in Njage and Miwangani they started in 2007. Sunflower crop is becoming famous in recent years in the study area because it tolerates moisture stresses. Similar studies elsewhere (Ellis, 2000; URT, 2007; Paavola, 2008; Sanga *et al*., 2013) have indicated how crop diversification is important as a way of adapting to the adverse effects of climate change.

Change in crop growing calendar was also observed by the majority of the respondents in the study villages (Table 5). The forest adjacent communities were shifting crop growing calendar through early cultivation since rains were neither reliable nor predictable. Early planting was claimed to be a viable climate change adaptation mechanism as it allowed optimization of unpredictable, unreliable rainfall by ensuring crops were already established on the farm when the rains commence. Focus group discussion noted that in the past decades (1990s and beyond) forest adjacent communities received first short rains in October to November and persisted till January. Currently, communities are using the first rains in November for crop planting, compared to the past where it was time for weeds to germinate.

With regard to adoption of modern farming, the study revealed availability of irrigation canal that was constructed in 2006 in Njage village to be used for rice production. The irrigation scheme was constructed in order to supplement water in some agricultural fields that were cultivated during dry season. In the 1990s and beyond, such fields used natural spring water and some intermittent rains which currently are not available. Similar findings were recorded by Sanga *et al.* (2013) in Pangani River Basin and Pemba in Tanzania where farmers use irrigation system to adapt with the adverse effects of climate change. In the current study, use of pesticides, herbicides and row planting instead of broadcasting seeds have also been adopted.

3.2.2 Response to floods

During FGDs the communities reported that, the government and some NGOs including the Plan International were involved in provision of camping facilities, food and health services during occurrence of floods. However, individually the forest adjacent communities claimed to respond to floods by increase their reliance to casual labouring, use of NTFPs than it used to be over the past decades and petty trade (Table 7).

Table 7: Developed climate change adaptation strategies by forest adjacent communities in the study area

Adaptation/coping	Responses (%)
Casual labour	20.2
Use of NTFPs	17.3
Selling livestock	6.2
Remittance	2.8
Petty trade	5.6
Selling rice and buying maize	1.1

From Table 7, some the forest adjacent communities were involved (20%) in casual labour activities for income generation in order to cope with the frequent floods that occurred in the study area. The use of NTFPs was also mentioned by a small proportion of respondents (17%) in the study area to cater for food, construction and generate income that was used for various domestic needs during times of hardship. However, majority of the respondents admitted to collect NTFPs unknowingly that they were responding to climate change adverse effects. The commonly mentioned NTFPs included mushrooms, firewood, medicinal plants and edible fruits. The mentioned NTFPs in the study area were illegally collected from the Iyondo Forest Reserve, in village woodlands and on farms. During FGDs communities mentioned that, village woodlands and on farms were the most reliable alternative sources of NTFPs that could provide the products if sustainably managed. Results imply that NTFPs could form part of the coping and adaptation strategies for communities' adjacent forest resources if well developed to ensure sustainability. Similar findings have been reported by Nkem *et al.* (2010) in the Democratic Republic of Congo (DRC) where communities have gone into commercialization of some NTFPs such as medicinal plants, mushroom, caterpillars, fish, bush meat and palm wine for climate change adaptation. This could apply to the people in Kilombero District if domestication and value addition could be emphasized for the existing NTFPs in order to enhance forest adjacent communities' adaptive capacity and in turn help to improve income and food security at household level. Adaptation through use of NTFPs has also been proposed in the IPCC Firth Assessment Report by Smith *et al.* (2014b) as important for the climate resilience of local livelihood systems because natural forests are more resilient to climate change effects than monoculture plantations.

The study has also revealed prevalence of a shift in use patterns of NTFPs from subsistence to trade for income generation (Table 8). NTFPs were both consumed and traded to get income that was used to carter for various human needs. To mention a few, firewood, medicinal plants and thatch grasses were among the NTFPs collected and traded in the study area. According to Nkem *et al.* (2010), NTFPs are essentially the niche for poor population, which make them relevant for addressing health problems, poverty, and adaptation to external shocks and stresses. The current study recorded higher values of annual average consumption of firewood that were traded than those used for subsistence which was 292.8±14.3 and 116.5±4.6 head loads respectively. Similarly, annual average consumption per household of medicinal plants and thatch grasses were also high (Table 8). This indicates that most of the forest adjacent communities used NTFPs for trade in order to get cash income that was used to carter for various household needs including health services, food and shelter.

Table 8: Use pattern of some NTFPs by households in the study area

Use pattern	Priority NTFPs	Annual average consumption per household
Subsistence	Firewood	116.53±4.63
	Medicinal plants	5.53±0.35
	Thatch grass	31.33±1.71
Trade	Firewood	292.8±14.27
	Medicinal plants	16.37±2.72
	Thatch grass	40.06±1.66

Note: Unit for firewood and thatch grasses was head load, equivalent to 16.55±3.33 and 14.12±3.19 Kg, respectively; while for medicinal plants was Kg.

Results revealed that the use of NTFPs for climate change adaptation was gender sensitive with both involvement of men (54%) and women (46%) for commodities such as mushrooms especially when agricultural crops were negatively affected (Table 9). In the past activities like mushroom and firewood collection were done by women only.

Table 9: NTFPs as adaptation to climate change adverse effects, in the study area

NTFPs	Responses (%)	
	Male	Female
Wild mushrooms	54.4	45.6
Construction materials (thatch grass, withies, ropes)	11.5	13.4
Firewood	14.0	15.0
Edible fruits	3.4	3.3
Edible tubers	14.3	10.0
Medicinal plants	3.4	3.9
Hyphaene compressa (H) Wendel. (*malala*)	53.3	27.3
Phoenix reclinata Jacq. (*ukindu*)	13.3	22.7

The difference in gender roles within NTFPs as adaptive measure among user groups in the two villages could probably be attributed to socio-economic factors within the gender roles, as collection of wild vegetable and mushrooms in the past was mainly done by females (Msuya *et al.,* 2010). Currently men in the study area have been forced by the climate change adverse effects to involve in some activities not used in the past in order to earn cash income. Similar results have been reported by Augustino *et al.* (2012) and Msalilwa *et al.* (2013) in selected parts of Tanzania. The findings in this study are also similar to those recorded by Nindi and Mhando (2012) in Mbinga District, where local communities used mushrooms, medicinal plants and construction materials as their immediate coping strategies to climate change effects.

On the other hand, use of weaving materials which were locally known as *malala* (*Hyphaene compressa* (H.) Wendel.) plant to make various products was revealed to be a strategic activity by more men (53%) compared to women (27%) in the study area (Table 9). This was due to the fact that women preferred much another type of weaving material known as *ukindu* (*Phoenix reclinata* Jacq.) due to its high value for the final product compared to *malala*. The use of NTFPs as an adaptation strategy is well emphasized in NAPA especially during periods of extreme weather conditions (URT, 2007). The study suggests the need to strengthen this type of adaptation to ensure sustainable livelihood of forest adjacent communities in future.

3.2.3 Response to pest and diseases

During FGDs, forest adjacent communities revealed to use different plant species for ailment, as a way to of respond to human diseases such as cholera, typhoid, dysentery and amoeba. Other ailments cured include malaria, stomach ache, skin rushes, cold and cough, as well as some non-communicable diseases like diabetes and hypertension. Government intervention was also reported which included provision of mosquito nets as a protective measure of malaria. Also during outbreaks of cholera, the government took care of all affected people through establishment of quarantine centres. In the quarantine centres people were provided with all necessary treatment and preventive measures against cholera. Frequent outbreak of pests and diseases necessitated forest adjacent communities to rely much on medicinal plants because most of them were not able to afford modern treatments because of either limited health centres or cash income. Most of the popular remedies were reported to be common to the majority of the local communities. Dependence on medicinal plants as a primary healthcare by rural communities has also been reported elsewhere by other scholars in Tanzania (Kitula, 2007; Otieno *et al.,* 2011; Kayombo *et al.,* 2013; Njana *et al*., 2013; Nahashon, 2013; Augustino *et al.*, 2014). Nkem *et al.* (2010) in DRC urged that dependency on traditional medicine is perpetuated by the fact that artificial medicinal care is limited in rural areas, and where it is available the costs are relatively high.

3.3 Socio-economic factors influencing climate change adaptation strategies

The results showed that, household size (X_2), duration the respondent lived in the study area (X_3), land ownership (X_5) and household income (X_6) are the socio-economic variables that influenced adaptation strategies positively and significantly at 5% probability level (Table 10). Age (X_1) of the respondent influenced adaptation strategies negatively however was significant at 5% probability level. Education level (X_4) influenced adaptation strategies positively but not significantly at 5% probability level. Forest access rules (X_7) influenced adaptation strategies negatively and insignificantly.

Table 10: Socio-economic factors influencing climate change adaptation strategies in the study area

Independent variables	One to three adaptation strategies						More than three adaptation strategies					
	β	S.E	Wald	t	Sig.	Exp(β)	B	S.E	Wald	t	Sig.	Exp(β)
Intercept	.490	.776	.399	1	.528	-	-20.921	4.939	17.940	1	.000	-
Age (X_1)	-.038	.016	5.819	1	.016*	.963	-.045	.127	.124	1	.725	.956
Household size (X_2)	.400	.081	8.569	1	.003*	1.269	.400	.332	1.451	1	.228	1.492
Residence period (X_3)	.007	.012	6.815	1	.009*	1.031	.007	.097	.005	1	.941	.993
Education level (X_4)	.464	3.059	1.235	1	.266	.629	16.251	3.059	.000	1	.998	.000
Land ownership (X_5)	16.399	.000	1.023	1	.312	.575	16.399	.000	.000	1	.000*	1.325
Household income (X_6)	.017	.042	3.093	1	.049*	1.031	.067	.097	.005	1	.941	.993
Forest access rules (X_7)	-.002	.385	.000	1	.996	.998	-1.655	7.261	.000	1	.998	1.5397

Note: Cox & Snell R-Square = 0.261; Nagelkerke R-Square = 0.342; β = regression coefficients which stand for the odds ratio of probability of success to the probability of failure, SE = standard error of the estimate, Wald statistics = Wald statistics denotes relationship between dependent and independent variables; df = degree of freedom, Sig. = significance or p values, Exp (β) = odds ratio (probability of success over probability of failure); *Statistically significant at $p < 0.05$ level.

Number of adaptation strategies was observed to decrease as the individuals in the household approaches old ages. The negative beta coefficient (β) indicates that as the age of the respondent increases, there is likelihood of decrease in the number of adaptation strategies a household develops as thinking and working ability becomes less. However, age was also significantly related to farmer's decisions during adoption to new technologies, thus affects adaptation to climate change (Dolisca *et al.,* 2006). Similarly according to Tazeze *et al*. (2012), as age of the household head increases, the person is expected to acquire more experience in weather forecasting that helps increasing the likelihood of practicing different adaptation strategies to climate change. All these could apply to forest adjacent communities in the study area when age is considered among socio-economic factors for adaptation.

Household size determines per capita livelihood diversification hence contribution to communities' adaptive capacity (Elis, 2000; Gbetibouo, 2009). Results revealed that household size had positive beta coefficient (β) suggesting influences on the number of adaptation strategies a household can contain. That implied a unit change in household size increases likelihood of increasing the number of adaptation strategies (Table 10). It is anticipated that, a household with large household number increase adaptive capacity to climate change (Nhemachena and Hassan, 2008; Aymone, 2009). A study by Giliba *et al.* (2011) in Babati district and Njana *et al*. (2013) at Urumwa Forest Reserve in Tabora region showed that household sizes facilitated the contribution of the livelihoods of local communities adjacent to forests resources. Similarly, Gbetibouo (2009) in South Africa revealed that a large household is more willing to choose the adaptation options that are labour intensive such as soil conservation techniques, developing irrigation schemes and chemical treatments.

The residence period the head of household lived in the study area had positive beta coefficient (β) suggesting that it influences adoption of developed adaptation strategies by forest adjacent communities. This implied that, a unit change in resident period increases likelihood of increasing the number of adaptation strategies (Table 10). There were however, no significant differences in residence period when more than three adaptation strategies were involved. It is speculated that more adaptation strategies were probably developed by people who lived in the study are for a long time because of increased experience, knowledge and gained information on adverse climate change effects. According to Ellis (2000) and Nhemachena and Hassan (2007) communities living for a long period in a certain area are able to develop large number of adaptation strategies.

Land ownership is about securing right to long term access to land and their benefits (Lutz *et al*., 1994). Results showed that land ownership had positive beta coefficient (β) suggesting that it influences the number of adaptation strategies especially when communities decided to have more than three options (Table 10). The variable was not significant at 5% probability level when communities opted to have two to three adaptation strategies. This could probably be associated with the security on land ownership as it enables communities to have various adaptation strategies developed on the land. Farmers who own their land are more likely to invest in various adaptation options, including crop and livestock management practices and water conservation. Studies show that land ownership encourages the adoption of various technologies linked to land including irrigation, drainage, tree planting and crop diversification (Lutz *et al*., 1994; Shultz *et al*., 1997; Nhemachena and Hassan, 2007).

Table 10 indicates that household income had positive beta coefficient (β) suggesting that the variable has influence on adoption of adaptation strategies the local communities developed. This indicates that, a unit change in this variable increases likelihood of increasing the number of adaptation strategies, which was statistically significant at 5% probability level ($p = 0.049$). It is hypothesised that households with higher income and greater assets are in better position to adopt new farming technologies. Findings in this study are similar to Deressa *et al.* (2009) and Tazeze *et al*. (2012) who found that household income had significant impact on increasing adaptation strategies which include, use of different crop varieties, irrigation technologies, early cultivation and changing planting dates.

Results have also revealed that education of the respondent had positive beta coefficient (β) suggesting that it influences the number of adaptation strategies, though was not statistically significant at 5% probability level. It is hypothesised that educated and experienced farmers have more knowledge and information about climate change, thus enabling them increase the probability of adopting new technologies (Adesina and Forson, 1995; Daberkow and McBride, 2003). Similarly, Tazeze *et al*. (2012) found that literate farmers are more likely to respond to climate change by making best adaptation options based on preferences and influences individual decision making.

Forest access is important when it comes on the issue of livelihood contribution to forest adjacent communities by increasing their adaptive capacity. The rules and regulations put on access to the forest resources often influence the livelihoods of the forest adjacent communites. Results showed that forest access rules had negative beta coefficient (β) in the study area suggesting its less influence on the number of adaptation strategies a household can contain (Table 10). As the beta coefficient of this variable was negative, it implied a unit change decreases the likelihood of increasing the number of adaptation strategies. In the study area, communities declared that, recently collection of forest products from Iyondo forest reserve (now part of Kilombero Nature Reserve (KNR)) and grassland is not granted, and thus access has been illegal for some of the local communities. Free access was on village woodlands and on farms where products were scarce to meet the increasing demand in times of climate stresses and shocks. Informal discussions with KNR conservators revealed that, some of the NTFPs were informally allowed to be collected from the nature reserve like mushrooms, wild fruits, wild vegetable and firewood. Law enforcement was mainly on harvesting timber, building poles and hunting of wild games in the reserve. However, not all of the local communities were well informed about the current prevailing legal status, and the need for raising awareness is proposed. The findings in this study are in line with those by Mombo *et al.* (2011) who indicated that, majority of the local people were not aware whether there was specific law prohibiting them from performing specific activities in the Kilombero Valley Floodplain Ramsar Site (KVFRS).

4.0 Conclusions and Recommendations

4.1 Conclusions

Forest adjacent communities perceive the climate to have changed as evidenced by increase in temperature and unpredictable rainfall over the past decades. This was further evidenced by frequent occurrence of floods, increased dry spells during rainy season coupled with decreased water sources, and emergence of new pests and diseases. The communities' perceptions are in line with existing empirical climate data for Kilombero meteorological station where temperature and rainfall have indicated an increasing trend with fluctuations in some years. The observed change has impacted different sectors with agriculture being the top most as the main livelihood source. The forest adjacent communities have responded differently to experienced climate change adverse effect by developing both coping and adaptation strategies. These include crop diversification, changing cropping calendar, adopting modern farming technologies, increasing reliance on NTFPs, animal rearing and petty business. Household size, residence period, education level, land ownership, household income, were the socio-economic factors that influenced coping and adaptation strategies positively and significantly in the area.

4.2 Recommendations

The study draws the following recommendations;

(i) There is an urgent need for provision of weather forecast information to the area for preparedness. The need for daily recording of climatic events by meteorological stations in the study area and other places in Tanzania is crucial for future confirmation of climate change.

(ii) The observed potential coping and adaptation strategies need to be prioritized, strengthened and developed to ensure livelihood sustainability in future.

(iii) Policy and decision makers within the natural resource sector should take into account climate change local adaptation strategies and address them well in relevant policies including the National Agriculture and Forest policies; NAPA and the National Climate Change and REDD+ strategies.

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